Technology Opportunity

Microgravity Microaccelerometer System

The National Aeronautics and Space Administration (NASA) desires to develop "sensors on a silicon chip" technology to measure very low levels of gravity (acceleration) in support of microgravity science experiments in space.

Potential Commercial Uses

- Measure best orientation of containers for semiconductor and protein crystal growth in space-commercialization facilities
- Measure acceleration and velocity for commercial airline navigation instruments and for automated automotive navigation systems
- Measure acceleration for automotive airbag and vehicle-suspension-stabilization systems
- Provide stabilized platform measurement for hand-held cameras
- Measure acceleration for military missile systems (higher gravity versions)

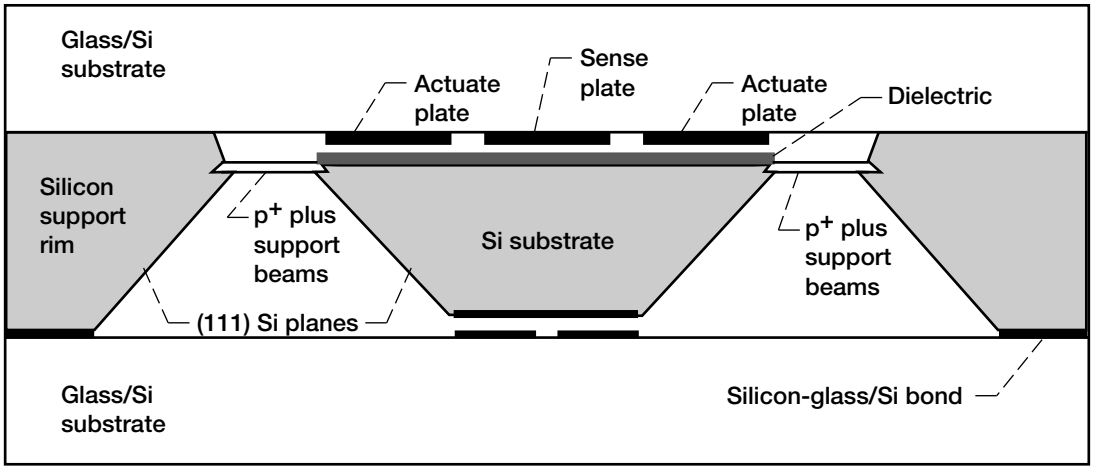
Benefits

- Provides microminiaturized sensor instruments for a variety of existing and new acceleration measurement applications.
- Combines sensors and interface electronics on multichip modules to reduce costs.
- Uses newly developed sensor-fabrication technology for multiple-unit production, resulting in very low unit cost.
- Reduces overall sensor system size, weight, power, and cost by several orders of magnitude.
- Can incorporate multiple sensor types on a chip for environmental sensing of acceleration, pressure, temperature, humidity, and other conditions.
- Transfers government-funded technology from laboratory development to cost-efficient uses in commercial and aerospace programs.

The Technology

Several different methods of fabricating microaccelerometers via silicon micromachining techniques are under evaluation for this program. One technique uses an all-silicon process, whereas another technique uses silicon and glass wafers as described in the following paragraph.

The figure shows the basic structure of a silicon microaccelerometer for this application, which consists of three wafers that are bonded together. The



Proposed structure of a silicon microaccelerometer for space applications.

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middle silicon wafer supports the proof mass and the support beams for the mass, and the top and bottom glass wafers support plates that form air-gap capacitors with the silicon mass. These capacitors are used both to sense the position of the mass and to provide an electrostatic attraction that balances the forces to keep the mass stationary. The inertial mass is attached to the surrounding silicon support rim through thin silicon beams. The boron etch-stop technique that is used to form the beam can create silicon structures as thin as a few micrometers to an accuracy better than 0.1 μm. Our analysis has shown that L-shaped support beams are most suitable for this application and produce the necessary spring constants and cross-axis sensitivity.

The characteristics of microaccelerometer fabrication technology follow:

- It is compatible with batch fabrication, is comparatively simple, and produces high yields.
- This technology allows for easy attachment to the electrical contact pads on the sensor substrate.
- The process sequence is designed so that the large proof mass and the delicate suspension beams are supported throughout the process so that they will not be damaged during the fabrication process and so that the possibility of any particulates getting inside the capacitive gap is minimized.
- The technology permits the easy formation of proof masses and beams with different shapes and thicknesses without the need for major modifications. This flexibility in setting dimensions and shapes is critical in optimizing the performance specifications.
- The proposed packaging/sealing for the microaccelerometer is compatible with a high yield; and in early tests, it has been shown to provide adequate sealing for barometric pressure sensors packaged with a similar process.

Options for Commercialization

- NASA has a major goal to transfer government-funded research technology transfer to industry and commercial applications.
- The Microgravity Microaccelerometer System (MGMAS) is currently intended to support future microgravity commercial product manufacturing in space.
- With small changes in design, the MGMAS could be fabricated for use in avionics systems of commercial and military aircraft.
- With additional changes, MGMAS could be designed to provide measurements, with a computer interface, for automotive systems.
- The MGMAS program received a commitment of $140,000 from a military avionics manufacturer to develop a version for use in a guided missile.
- Commercial acceptance of microelectromechanical systems (MEMS) is becoming more widespread because of their overwhelming advantages in size and cost and their adaptability for multiple uses.

Contact

Commercial Technology Office
Attn: TOPS
NASA John H. Glenn Research Center
at Lewis Field
Mail Stop 7–3
21000 Brookpark Road
Cleveland, OH 44135–3191
Phone: 216–433–3484
Fax: 216–433–5012
E-mail: cto@grc.nasa.gov
http://cto.grc.nasa.gov

Key Words

Microgravity
Microaccelerometer
Micromachining
MEMS
Inertial sensors